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Towards a revolution in operational strategy —Co-engaging Production

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Abstract: A revolution in operational strategy is emerging because of the renaissance of decentralized production and the renaissance of non-Occidental engineering and science. The contribution of this conceptual paper is that it (i) assesses the revolution in its historical context, (ii) defines the contemporary iteration of decentralized production in addition to establishing the revolution's foundations for innovation, legitimization, ethics and morals, (iii) shows that business theories on competences, resources and competitive advantage developed for firms engaged in centralized production are inadequate for decentralized production in fluid networks, (iv) identifies the cognitive challenge in taking full advantage of the diverse knowledge in decentralized production, and (v) finds that legal instruments which have developed alongside centralized production impede the revolution in operational strategy. The objective of this paper is to explore the impact of the renaissance of decentralized production, in the form of Co-engaging Production, on the dynamics of competences, resources and innovation in the emerging multipolar world.

Keywords: cognition; cooperative strategies; engineering; innovation; international management

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经营战略的革命
——合作生产

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摘　要：随着分散生产和非西方工程、科学的复兴，一场经营战略的革命正在崭露头角。这篇理论性论文的贡献在于：(i)评估了革命所处的历史背景；(ii)定义了分散生产的当前迭代，同时建立本次革命创新性、合法化与道德伦理的基础；(iii)表明了关于开发能力、资源和竞争优势的集中生产企业的商业理论，不适用于流体网络中的分散生产；(iv)识别了充分利用分散生产的多样化知识过程中遇到的认知挑战；(v)发现了与集中生产共同发展的法律文书阻碍了经营战略的革命。本研究旨在探讨以合作生产形式进行的分散生产的复兴对新兴多极世界的能力、资源和创新动力的影响。

关键词：认知；合作策略；工程；创新；国际管理

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1　Introduction

After centralized production has dominated operational strategy in the Occident for the last 700 years, environmental, health and economic crises have weakened the domination of the Occidental operational strategy that has traditionally been based on centralized production and economies of scale. The revolution in operational strategy is associated with (i) the renaissance of decentralized production enabled by innovative engineering and powerful ICT (Information and Communications Technology), and (ii) the renaissance of non-Occidental countries with their own traditions in the fundamentals of innovation: engineering and science (the term"science"is used in the connotation of natural science). Although non-Occidental producers have adhered to Occidental engineering and science because of their need to export to Occidental markets in the past, the strengthening of the domestic demand in non-Occidental markets is creating a demand for products based on non-Occidental engineering and science.

Moreover, the revolution in operational strategy creates gaps in the business concepts that deal with the dynamics of competences and resources which form the foundation of competitive advantages. The problem is explicit and implicit assumptions. When schools of thought based on Wernerfelt[1], Prahalad and Hamel[2], and Teece, Pisano and Shuen[3] are considered, then there is an explicit assumption that the phenomena occur in firms. This assumption does not hold in contemporary decentralized production (Co-engaging Production) occurring in the context of individuals co-engaging in fluid networks.

Drawing any implicit assumptions is substantively problematic, because contrary to explicit

assumption they are not clearly visible. Even more problematic is the situation when a business concept is superficially neutral, but in reality it is consciously or unconsciously based on an assumption that is not neutral. One such implicit assumption in Occidental business concepts is that there exists only one global engineering and science that incidentally is Occidental engineering and science. Such an implicit assumption is problematic in an increasingly multipolar world, especially in light of the renaissance of non-Occidental countries. Implicit assumptions is problematic in business research, because they prevent a discourse. It is obviously difficult to refer to an assumption of a business concept and debate it if this assumption is never spelled out clearly.

Contemporary decentralized production occurring in fluid networks makes it possible to mobilize non-Occidental engineering and science for innovation. This diversity is not about ethnicity, gender, religion or sexual orientation per se. It is rather about different societies with their respective engineering and science. In order to mobilize the maximum potential of this diversity, sufficient cognitive distance and absorptive capacity are needed[4-5].

The revolution in operational strategy also has implications for ethical and moral considerations in production. On the one hand, the renaissance of decentralized production means a re-convergence of ethical, moral and operational decision-making into the hands of the individual co-engaging in decentralized production. On the other hand, the renaissance of non-Occidental countries means an increasing role for non-Occidental ethics and morals in decision-making.

The renaissance of decentralized production is hampered by legal concepts developed in the context of the dominance of centralized production over the last two centuries. Changes to legal concepts will be needed in conjunction with changes to the way we can conduct business research, engineering and science.

This paper is conceptual. There are several reasons precluding an empirical approach. These reasons include the unavailability of statistical data on production activities of individuals not running their own firm, the impossibility of identifying such individuals in a statistically representative way, and the relatively early development stage of the revolution in operational strategy.

The objective of this paper is to explore the impact of the renaissance of decentralized production in the form of Co-engaging Production on the dynamics of competences, resources and innovation in the emerging multipolar world.

2 On revolutions in operational strategy

A revolution is about a fundamental contradiction. A revolution(i) is the result of failure that makes discontinuous change necessary, and (ii) confirms the need to connect with the past to reduce the fear of change and thus legitimize change. This connection is not about restoration of the past stricto sensu but rather about a renaissance of modern decentralized operational models. A revolution establishes a new starting point in the form of a tacit social consensus for evolution. Such an evolution is characterized by an increasing radicalization over time that plants the seeds for crisis and the need for a later revolution.

The term“revolution”has to be used carefully. It might be tempting to call mere evolution a revolution, but such careless use of terminology makes meaningful analyses challenging. Keeping the terms“revolution”and“evolution”apart in the research of operational strategy is made more difficult by the circumstance that neither is a discrete event or development, but both are found on a

continuum spanning from stagnation to revolution. What is singular in a revolution in operational strategy is that it sets simultaneously into motion discontinuous changes in three major dimensions and the interaction of these three dimensions. The three major dimensions are: (i) Ethics and morals, (ii) business, and (iii) the application of natural science and ICT.

Revolutions are exceedingly rare. An analysis of frameworks related to operational strategies suggest much longer periods from revolution-to-revolution than the long waves of roughly 50 years proposed by Nikolai Kondratiev. His proposal is based on several factors, among them innovation. Joseph Schumpeter, on the other hand, sees everything to be based solely on innovation[6]. The difference between Kondratiev and Schumpeter does not need to be significant, when considering the object of innovation to be the entire technical system[7], an approach that is not dissimilar to the very broad definition of technique proposed by Ellul[8].

The fundamental reason for the rarity of revolutions is that evolution and radicalization within the confines of a tacit social consensus after a revolution allows for significant technology-related change without requiring discontinuous changes in business, and particularly ethics and morals. In the Occident, only three revolutions in operational strategy can be identified in the last 2000 years, i.e., (i) the commencement of the decline of centralized production in the urban centres of the Roman Empire in the 3rd century, (ii) the Renaissance (of Antiquity) and the commencement of the trend toward the dominance of centralized production in the 14th century, and (iii) the renaissance of decentralized production in the 21st century.

The foundation of the revolution in the 14th century can be seen in the diffusion of the Italian Model[9-11]. In the three revolutions, deep and traumatic social crises caused operational revolutions, i.e., the decline of the urban centres and the existential crisis of the West Roman Empire in the 3rd century, the defeat of the Occident in the Crusades with the fall of Acre in 1291, and the current ecological crisis. The incorporation of the three dimensions, i.e., (i) ethics and morals, (ii) business, and (iii) the application of natural science and ICT, into the determination of the occurrence of a revolution means that the First Industrial Revolution in the 18th century, Second Industrial Revolution in the 19th century and Third Industrial Revolution in the 20th century were and are merely three evolutions and radicalizations of the revolution that occurred in the 14th century which saw the emergence of the Putting-out System.

Gaining knowledge about revolutions in operational strategy is hampered by the scarcity-at best-and absence-at worst-of business literature prior to the 20th century. What can be attempted is to reconstruct operational strategy and changes therein based on sources related to archeology, history, political philosophy and political economics. To anticipate the findings of the analysis of the period from the 14th century to the 20th century, operational strategy was characterized by an increasing dominance of centralized production, an increasing reliance on economies of scale, an increasing standardization of products, an increasing complexity of value chains, and an increasing conflict between the ethical and moral dimensions, and of operational strategy. Revolutions are more than issues related to the micro-and meso-levels analyzed in the literature[12]. Revolutions are about the macro-level, i.e., a discontinuous change in the dominant operational strategy. It is necessary to comprehend the cultural, political and social roots of modern management in order to understand the rationality of modern production[13].

In Occidental economic thinking, the basis of the value of a product has changed from the sum of

its theological value, objective utility and just, meaning fair, market price in the thinking of Saint Thomas Aquinas in the 13th century; the costs of land and labour contained in the product in the thinking of Richard Cantillon in the early 18th century; to the combination of the production costs and the perceived value by its buyer in the thinking of Turgot[14].

Montchrestien[15-16] published the recommendations made to the French king in 1615 which included issues related to the different sectors of the realm's economy and thus had relevancy to operational strategy in production. From the standpoint of the dimension of ethics and morality, it is noteworthy that the king was encouraged to make sure that virtue and morality was adhered to in society[17], and this would have naturally included all business activities. Specific advice on the size and organization of production operations is not offered, but Montchrestien's advise that the production should occur in France rather than in foreign realms contains a seed for the adoption of operational strategies practised abroad and thus centralized production.

Colbert advised the French king to support the establishment of large-scale manufactures while keeping in mind the king's ethical and moral obligations. This advice is a radicalization in relation to Montchrestien's thinking about production and a milestone on the way to more centralization in production over the following three centuries.

The possibility of harnessing ICT capabilities, specifically Computer Integrated Manufacturing, to break the dominance of centralized production and the production of standardized products was not taken advantage of until the 21st century[18-20]. The domination of standardized products was questioned after the discovery of the Japanese manufacturing concept in the Occident, and the prospect of volume flexibility and product flexibility in production received attention in the late 20th century[21]. The ensuing years saw a gradual destabilization of the standardized product approach with the emergence of new production concepts,e.g., Flexible Manufacturing, Mass Customization, Agile Manufacturing and Fit Manufacturing. These concepts did not necessarily question the rationale of centralized production[22-25]. The aforementioned frameworks were devised in the context of discrete manufacturing and as a consequence they were very difficult to apply in energy generation, services and chemical engineering-based production processes.

There is some amount of relativity in the determination of centralization and decentralization. This can be observed in the outsourcing debate. Over more than three decades, the debate has focused on the outsourcing of activities of firms to other firms[26-27] and in some cases individuals. This has not been a one-way street. At the same time, it can be noted that individuals have outsourced their activities to firms as the centralization of production has increased.

The terms co-creation and co-production have been used in a way that implies that a value chain consists of at least one firm and one consumer who are in cooperation with each other[28]. The consumer participates in the value chain in a process that includes "*an integration of physical activities*, *mental effort*, *and socio-psychological experiences*" by providing "*money*, *time*, *effort*, *and skills*"; and taking the form of "*procuring*, *assorting*, *moving*, *combining*, *and changing inputs*", "*planning*, *evaluating*, *monitoring and regulating progress*" and "*socio-psychological experiences*" thus becoming a prosumer[29]. Such a view does not take into account that the emergence of ICT in combination with changes in engineering may make such value chains feasible that consist of only individuals.

Recombination is considered a path to innovation, but recombination does not necessarily work

in the case of a revolution in operational strategy. In the aftermath of a revolution, the foundation of a recombination has to be the new dominant operational strategy except for the niches in which the previous operational strategy still survives. This limits the usefulness of recombination significantly.

Decentralization of production and increasing flexibility in production has the propensity to increase transaction costs. Certainty about engineering and standardization reduce transaction costs[30-32], but the loss of certainty and previous standards as the result of a revolution has the opposite effect. The revolution ushering in a renaissance of the dominance of decentralized production will not only bring benefits. It will have a cost disadvantage in relation to transaction costs.

3 On Co-engaging Production

Co-engaging Production can be defined thus: Co-engaging Production encourages individuals to cooperatively unleash their capabilities, competences and creativity throughout the value chains thus creating individualized products and production processes. In its purest form, networks in Co-engaging Production consist primarily of individuals, but it is possible for a small number of like-minded individuals to take the place of an individual. The interactions between the self-selected actors are dynamic and change from product-to-product and over time. Each actor makes its own decision on joining the cooperation, and thus the result is a self-selected co-engaging network.

Co-engaging Production is enabled by innovative engineering and powerful ICT. Fig. 1 summarizes the key aspects of Co-engaging production which will be assessed throughout this paper.

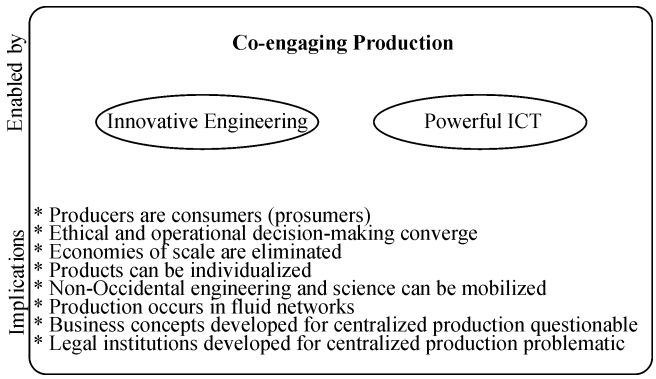

Fig. 1　Key aspects of Co-engaging Production

The first examples of a renaissance of decentralized production and its contemporary iteration, Co-engaging Production, can be discerned. These examples include: (i) small-scale discrete manufacturing using 3D printing; (ii) decentralized electricity generation with solar panels installed on the roofs of residential buildings; (iii) the emergence of microbreweries; and (iv) the design and production of individualized garments. These examples are merely a few of the harbingers of the revolution in operational strategy.

Co-engaging Production is a revolution, because it means the renaissance of the dominance of decentralized production. Co-engaging Production enables a stronger integration of ethics and morals in business-related decision making in addition to a change in the direction in business. With its decentralization, Co-engaging Production is close to the organic organizational model and a repudiation of the mechanical organizational model-both models being analyzed and rejected by Burns and represents Stalker[33]. It can be questioned whether Co-engaging Production can be described as

an organization or network, because it includes a significant degree of fluidity among the co-engaging individuals that one might expect from an organization or network. With this caveat, the term "network"will be used because of the lack of a better term. It is warranted to speak specifically about fluid networks.

The individualization of products and processes requires co-engaging innovation, and this happens in fluid Co-engaging Production networks. They differ from the interactive innovation networks described by several scholars[34-35] in one key aspect: in Co-engaging Production networks, innovation centres round a single individual, the consumer, but in interactive innovation networks a wide array of firms collaborate with the consumer being left on the sidelines. The focus on a single individual, the consumer, brings Co-engaging Production closer to the idea of a lone innovator. This single innovator-focused approach was prevalent before the idea of interactive innovation networks gained ground in the second half of the 20th century.

Co-engaging Production is expected to benefit from a virtuous innovation cycle as co-engaging individuals gain skills therein. As suggested by several scholars[36-37] for services, the increased skills gained by the consumers in the course of co-creation increases the likelihood of additional co-creation in the future. There is no fundamental reason to limit this to services. Co-engaging Production has to contend with the fundamental contradiction that bedevils learning and knowledge-based organizations, and societies, and this matter has been discussed by several scholars: the uncertainty introduced by learning, on the one hand, and the human basic need for security, on the other. In order to be successful, Co-engaging Production has to navigate this apparent contradiction.

March[38] pointed out that exploration in the context of innovation requires "foolishness", a characterization that can be understood against the backdrop that an innovator has to leave the comfort zone behind and embark a Terra Incognita. The amount of"foolishness"has to be much larger when the change is much bigger, as in the case of a revolution of operational strategy exemplified by Co-engaging Production.

The decentralization associated with Co-engaging Production will strengthen the argument for the scholars who have argued that ICT favours decentralization. In the early days of ICT, some scholars assumed that ICT would result in a centralization of decision-making in organizations and flattening of organizational pyramids[39-40]. Some other scholars assumed that ICT would result in decentralization[41]. It has been concluded that ICT promotes lateral communication, information exchange and distribution of knowledge-this does not necessarily result in any particular type of organization[42]. However, Co-engaging Production may favour some ICT-related centralization, if centralized Internet platforms are used.

There is an interaction between Co-engaging Production and the development of ICT. Some scholars[43] argue that failures in ICT projects are often caused by a deterministic view of ICT. They propose that ICT projects should be based on co-construction. This proposal effectively means that the realization of co-construction would mean that not only the decentralized production enabled by ICT would be based on co-engagement but also ICT has to be based on co-engagement. The need for co-engagement in ICT is particularly pressing when individuals who belong to linguistic groups and indigenous peoples with no or very limited computer platforms available in their languages. A challenge in a Co-engaging Production network is how individuals can establish legitimacy within the network, and how a Co-engaging Production network can establish legitimacy within society[44-46].

The legitimacy challenge will probably be particularly difficult for linguistic minorities and indigenous peoples. Without legitimacy, individuals may be disinclined to enter into transactions with other individuals.

A way to have legitimacy would be that the engaging individuals were part of a group with strong reciprocal ties. Although such strong ties are reminiscent of 19th century paternalism, Co-engaging Production is its opposite. Paternalism is based on mutuality[47], i.e., the employee offers discipline and loyalty, and the employer offers protection. In Co-engaging Production, there is no discernable employer, and thus the foundation for paternalism is not given. In the establishment of the needed ties, fairness is a key issue. Fairness-related considerations impact the outcome of negotiations about forming an alliance[48]. As a Co-engaging Production network can be compared to an alliance, it stands to argue that fairness-related issues are of importance in Co-engaging Production as well.

Another dimension of reciprocity, or mutuality, is the emergence of a shared identity among individuals engaging in a particular case of Co-engaging Production. If the engagement results in the emergence of a sufficient level of homogeneity among the individuals, then an external threat will be tackled jointly[49-50]. These findings deal with business threats, and their applicability to other threats like mutual assistance in the case of natural disasters and illness-arguably an ethical and moral imperative-is not self-evident.

Co-engaging Production takes advantage of the potential of incorporating ethical and moral aspects into production, a potential identified by several scholars[51-52]. Analogously with corporate social responsibility[53], the success of a Co-engaging Production network may strongly hinge on its perceived social responsibility, because it attracts individuals to co-engage and establishes legitimacy.

The Co-engaging Production networks may be asymmetric[54]. This is caused by the greater knowledge of the culture of another individual by an individual. This greater knowledge can be rooted in past trade patterns and can be favoured by a syncretic culture. One case is that asymmetries-information asymmetries-favour alliances over acquisition[55], and thus also decentralization over centralization, thus making Co-engaging Production advantageous in a multipolar world.

A caveat is required at this point. All concepts and studies assessed in this section (i) deal with firms and organizations, and (ii) originate from the Occident. This is a very different foundation compared to that in Co-engaging Production (individuals co-engaging in fluid networks) in a multipolar world (the dominance of the Occident declines with the commencing renaissance of non-Occidental countries like China and India). The validity of the concepts and studies has to be verified in the new reality.

4　On competences, resources and competitive advantage

In Co-engaging Production, competences and resources are mobilized and competitive advantages achieved by co-engagement, i.e., something reminiscent of collaboration. Co-engaging Production goes further than Collaborative Network that merely brings firms together[56]; networks in Co-engaging Production bring collaborating individual consumers into the value chains. Thus, dynamic capabilities are not limited to firms as implicitly suggested in the literature, but they are needed by individuals as well. Similarly, it is insufficient to consider innovation only in the context of entrepreneurs, firms and interfirm competition as done by several scholars[57]. Co-engaging Production extends the context of innovation acknowledging that innovation may occur in the context

of more or less fluid networks as well.

In Co-engaging Production, customers play a dual role of producers and consumers (prosumers). Considering that networks are more or less fluid in Co-engaging Production, the sources of core competences become arguably more fluid. Core competences are the foundation of the success of firms. In a similar manner, it can be stated that core competences-based success in more or less fluid networks in Co-engaging Production are vested in the individuals participating in co-engagement.

Using the competence approach, it has been argued[58] that a firm faced with change in the needed competences can try to mobilize the competences of its clients, or it can opt for pure exploration. A significant level of rigidity imbedded in the value chains in the absorption of new competences can be discerned in this argument. In Co-engaging Production, networks may be sufficiently fluid that such a rigidity can be avoided completely or to a great degree. Prosumers may exhibit rigidity, but as buyers of products such rigidity is simply market responsiveness.

In Co-engaging Production, the distribution of resources along the value chains is different from that found in different iterations of centralized production. This has implications to the application of the resource-based view of the firm. Co-engaging Production brings a third resource to the two resources traditionally considered in the resource-based view of the firm, i.e., resources acquired on the factor market and resources developed within a firm[59]. This third resource is the consumer. The consumer is the only one who can define what to produce and how to be produced in order to fulfill the consumer's preferences. Production resources are not an extension of a firm's assets contrary to what has been suggested by several scholars[60-62]. This fails to recognize the decisive role of the consumer-producer in the value chain-that they are an extension of individual consumer-producers. Interconnected prosumers can not be compared to interconnected firms, and this makes the use of the work on interconnected firms[63] problematic in the case of Co-engaging Production.

The fluidity of the networks in Co-engaging Production highlights the importance of weak ties[64] in the transactions. A key resource in Co-engaging Production is the extent individual prosumers can mobilize weak ties successfully.

At first glance, Co-engaging Production is more a framework for "exploitation" than for "exploration", using these two terms in the sense of March[38]. A closer look suggests that this is not necessarily the case. Innovation has been divided into renforcement(enforcement), renouvellement (renewal) and exploration(exploration) as a function of the degree of the expansion of technological potential and the expansion of potential value[65]. It can be argued that individuals do not always have the resources to carry out innovation relating to renewal and exploration, it can be equally well argued that there are situations in which individuals have the necessary resources. Particularly when Co-engaging Production succeeds to mobilize individuals exhibiting great diversity, networks in Co-engaging Production may be particularly successful in renewal and exploration.

In Co-engaging Production, prosumers can be considered entrepreneurs even if they only produce for themselves. Entrepreneurship is based on economic and social considerations[66], and this brings social issues into decisions in Co-engaging Production. Business opportunities, autonomy, the challenge, personal fulfillment and the desire to participate in the entire value chain have been identified as reasons for entrepreneurship[67], but ethical and moral motivations are missing on the list. This is surprising in the view of the importance of diversity and environmental matters in innovation.

Again, a caveat is in place. All of the concepts and studies are from the Occident. They may not be valid outside of the Occident.

5 On diversity in Co-engaging Production

Individuals, and by extension firms, are not only different regarding the knowledge they possess, but they are also different in the way they perceive and interpret reality-this is called cognitive distance[68]. In order for cognitive distance to result in innovation, there has to be the ability to receive and process the knowledge of another individual-this is called absorptive capacity. In order for both absorptive capacity and cognitive distance to be a constructive force in innovation, the recipient has to be willing to absorb knowledge. The unwillingness to absorb heterodox knowledge contributes to a radicalization of an operational strategy over time and to the dominance of exploitation instead of exploration. There may be only one way to guarantee the emergence of the necessary willingness to absorb heterodox knowledge: This is an existential crisis of the incumbent operational strategy.

If absorptive capacity is considered a complex organizational characteristic as has been done by some scholars[69], then the question is whether a network in Co-engaging Production can be considered comparable to such an organization in regard to absorptive capacity. The fluidity of the networks in Co-engaging Production emphasises the role of individuals in absorptive capacity, because the choice of co-engaging individuals testifies to the willingness to absorption and ultimately determines the degree of absorptive capacity. A limitation to absorptive capacity is the cumulative and path-dependent characteristics of knowledge studied in the literature[70], a characteristic that can be reasonably found in individuals and organizations alike. A network in Co-engaging Production may be sufficiently fluid that rigidities related to the cumulative and path-dependent characteristics do not form, but such rigidities can be expected to form in the individuals.

If the claim is accepted that disruptive innovation is the result of chance and is based on science[71], and that the success of its exploitation is uncertain, then the issue is whether Co-engaging Production is conducive for disruptive innovation. The result can cut either way. A lot more individuals potentially engage in Co-engaging Production than do in centralized production, thus increasing the chance of the emergence of a novel or even heterodox idea. Co-engaging Production holds the promise of engaging people from different societies and cultures with different interpretations of natural phenomena, e.g., Indian science, Occidental science and Sino science. In keeping with the view that science is a social construct, such diversity increases the likelihood of disruptive innovation[72]. Another way to consider different sciences is to consider them based on different sets of paradigms, relevant problems, models and patterns of inquiry according[73].

A broad engagement conducive to the co-engagement of individuals who have had no discernible voice in innovation rests on one critical factor. Barriers to broad co-engagement and barriers to engagement by different sciences have to be eliminated. Such barriers range from easy to solve, e.g., the availability of ICT, to those challenges more difficult to solve, e.g., eliminating cultural and linguistic barriers. Considerable effort has to be spent on creating a space for fruitful engagement characterized by diversity[74].

Knowledge diversity is viewed as a key factor in recombination and thus innovation[75]. The knowledge diversity argument is close to the tension view of innovation, a view that claims that deep

knowledge of one scientific domain impedes breakthrough innovation, and that it often is necessary to break down the boundaries of single scientific domains to enable breakthrough innovation[76-77]. It has been argued by proponents of the foundational view that breakthrough innovation requires deep knowledge of a single scientific domain[77]. In either view, cognitive barriers prevent transfer of knowledge between individuals[78], barriers which are arguably higher between individuals hailing from different sciences than the same science. The cognitive barriers preventing knowledge integration are more profound for innovation than the cultural barriers discussed in the literature. The cognitive barriers can prevent individuals from taking advantage of the innovation potential embedded in the different knowledge profiles and diverse clusters of knowledge analyzed by several scholars[79-82]. To counter this, in addition to dealing with institutional challenges, it has been suggested that regional networks could be set up[4]. This would however mean that the potential of recombination-based innovation would be reduced because of fewer and more restricted interactions across barriers.

Co-engaging Production is about co-engagement across cultural boundaries, but it is not about imposing one cognitive map and one interpretation of Nature around the world. Fig. 2 shows that the realization of the innovation potential inherent in Co-engaging Production requires that the cognitive distance and absorptive capacity need to be broadened horizontally within Occidental engineering and science, and simultaneously they need to be increased vertically to be open to non-Occidental engineering and sciences. Any imposition or convergence of the factors contributing to diversity would reduce global cognitive and scientific diversity and thus it would reduce future innovation potential. It is necessary to maintain cognitive distance.

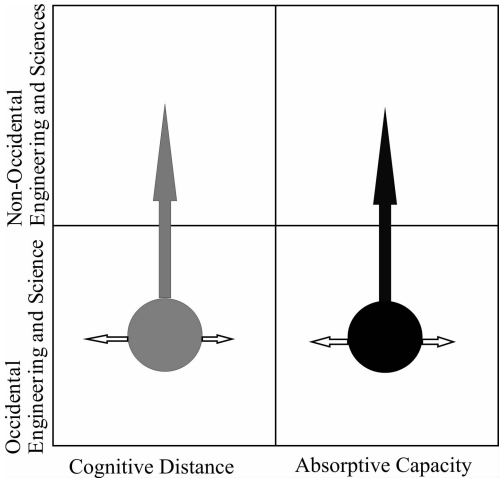

Fig. 2 Realization of the innovation potential inherent in Co-engaging Production

6 On legal implications of Co-engaging Production

A revolution in operational strategy means that the legal and social institutions which have been developed in interaction with the previous dominant operational strategy are not necessarily workable any longer. Finding solutions in an increasingly multipolar world will be challenging, because the two legal systems based on Roman Law-the Romanic-Germanic System and the Common Law System-will lose their global dominance. In this context, four legal institutions are of particular interest for further research:

(i) Contract Law: Contract law is a key institutional issue in the efficient functioning of value chains[83], and this will also be the case in Co-engaging Production. Because Co-engaging Production is based on individuals often with limited resources, there needs to be a simple and low cost way for litigation when needed.

(ii) Intellectual Property Law: Intellectual property law has been developed in conjunction with the radicalization of centralized production in the 19th and 20th centuries. A sanction can only be efficient if the likelihood of being detected is significant[84]. Claiming and enforcing intellectual

property rights has been feasible as long as the number of producers has been limited, but a revolution that results in the dominance of decentralized production undermines the foundations of intellectual property law.

(iii) Health and Social Insurance Law: Health and social insurance law has been developed in the context of employment contracts encompassing an employer and an employee. In Co-engaging Production, the foundation of employment contracts does not necessarily exist any longer resulting in a large number of individuals not being covered and threatening the financial basis of the health and social insurance plans.

(iv) Environmental Law: A challenge will be the redistribution and proliferation of industry-like emission sources.

7 Conclusion

Two renaissances reoccurring simultaneously are substantively changing the foundations of operational strategy, engineering and science. First, the renaissance of dominating decentralized production has commenced, being enabled by innovative engineering and powerful ICT. The contemporary iteration of decentralized production is Co-engaging Production, an operational strategy that allows for small-scale production of individualized products. Second, the renaissance of non-Occidental countries, including China and India, has commenced. Although this second renaissance has happened within the confines of Occidental engineering and science, it must be expected that this will not remain so as the domestic markets of the non-Occidental countries strengthen, e.g., China and India.

The contributions of this conceptual paper are:

(i) Revolutions in Operational Strategy: The historical development of the dominance of centralized production and the commencement of the renaissance of decentralized production are assessed.

(ii) Co-engaging Production: The contemporary iteration of decentralized production, Co-engaging Production, is presented. The renaissance of decentralized production has the potential to improve the performance of production in terms of innovation, legitimization, ethics and morals.

(iii) Competences, Resources and Competitive Advantage: The assessment demonstrates that the move away from firms taking advantage of economies of scale in centralized production to individuals operating in fluid networks in decentralized small-scale production means that the level of analysis of much of the literature on competences, resources and competitive advantage are not valid any longer.

(iv) Diversity in Co-engaging Production: The assessment shows that the renaissance of decentralized production contains the possibility of mobilizing knowledge that has not been used for innovation in any significant way in the last centuries. The practical benefit from this potential may be compromised by the self-selection of individuals co-engaging in a particular fluid network as the result of cognitive limitation.

(v) Legal Implications: Legal instruments have been developed alongside the dominance of centralized production. The assessment attests that the legal instruments are poorly equipped to handle the renaissance of decentralized production, and they may be an obstacle to the renaissance.

The limitations requiring additional research are:

(i) Empirical Research: Although some examples of the renaissance of decentralized production

associated with a corresponding decline of centralized already exist, this revolution in operational strategy is just commencing. Empirical research into the specific contents, dynamics and extent in different value chains is still needed.

(ii) Theoretical Research: As this paper has demonstrated that much of the past relevant research has focused on firms and centralized production, existing theories need to be modified and/or new theories developed to describe and explain the dynamics in fluid networks of decentralized production in a world that is not dominated by the Occident.

(iii) Engineering, Science and Cognition: The renaissance of non-Occidental societies raises the issue of the future role of non-Occidental engineering and sciences in innovation, and the cognitive foundations of differences between Occidental engineering and sciences, and their non-Occidental counterparts.

The revolution in operational strategy associated with the simultaneous renaissance of decentralized production and non-Occidental countries will significantly alter innovation and production. Although centralized production will not disappear, its role will diminish. The renaissance of decentralized production will substantively change the dynamics and interrelationship of ethics, innovation and production operations.

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